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Behaviour of Partially Closed Stiffened Cold-Formed Steel Compression Member

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Abstract Usually, thin-walled open column sections have an intrinsic weakness in their low torsional strength, which is unpleasant for resistance of an open section. The distortion behaviour of cold-formed steel open section has a significant role in structural steel design. Hence, initiativeness is made for converting partially closed section by adding simple spacer plates connected with self-tapping screws. The intend of this work is tested to estimate the competence of this solution by comparing the strength and performance of partially closed and open stiffened complex channel section under axial compression. The buckling characteristics of the section are computed using the linear elastic buckling analysis program CUFSM. The resistance and behaviour of the intermediate columns are examined in detail using finite element analysis software ANSYS. A good conformity between finite element analysis and experiments is found. The nominal design capacities are evaluated using the necessities of the direct strength method, North American iron and steel specification and Indian standard and are compared with those from test and finite element analysis. After this verification of the numerical model, a crucial parametric study is carried out to inspect the effect of vitiations on thickness, depth, spacing and slenderness of spacer plates. The particulars of this study and results are offered in this research article.

Keywords Partially closed column · Stiffened column · Spacer plates · Numerical analysis · Distortional buckling · Intermediate column

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List of symbols

b	Length of spacer plate (mm)
C	Centre-to-centre distance of spacer plate (mm)
d	Depth of spacer plate (mm)
E1	Size of lip (mm)
E2	Size of flat width of flange element (mm)
E3	Size of stiffened element (mm)
E4	Size of flat width of web element (mm)
E5	Size of intermediate stiffener (mm)
L	Length of column (mm)
P_{ANSYS} or P_{U}	Finite element ultimate load (kN)
P_{EXP}	Experimental ultimate load (kN)
P_{DSM}	Ultimate load using DSM (kN)
P_{AISI}	Ultimate load using AISI (kN)
P_{IS}	Ultimate load using IS (kN)
P_{Y}	Yield load (kN)
SC	Stiffened column
SP	Spacer plate
SD	Standard deviation
T	Thickness of the section (mm)

Subscripts

ANSYS	Finite element software
EXP	Experimental
DSM	Direct Strength Method
AISI	American Iron and Steel Institute
IS	Indian Standard
Y	Yield load

1 Introduction

All over the world, applications of thin-walled sections have been a growing demand in all the engineering industry due to their low self-weight, high performance of structural systems with uniform quality, simple fabrication process and cost-effective in both transport/erection. Cold-formed steel sections can be used effectively as a structural element in cases where hot-rolled sections or others are not efficient. The buckling behaviour of the thin-walled column is governed by various parameters such as cross-sectional geometry, dimensions and slenderness ratio.

The instabilities of thin-walled compression members are local, distortional, flexural torsional buckling and their interaction between them. The prime failure mode of the column is local and distortional buckling. Generally, cold-formed thin-walled section has a high plate slenderness ratio and hence a member buckled locally before reaching the yield load. Local buckling of a thin element does not lead to failure. Distortional buckling occurs at intermediate column, and it is characterized by displacement of the element normal to the plane of the element. And also distortional buckling plays the important role in the design of cold-formed steel column. Normally, long column fails by flexural buckling. In this mode, excessive deformation occurs about a weaker principle axis. This mode of failure can be delayed / eliminated to have a significant change in overall performance of the compression member. However, in the industry, the open C-channel sections are commonly used in cold-formed steel design. The performance of cold-formed steel members is influenced by the material and sectional properties of the section; it can be improved by a variety of ways. The behaviour of the cold-formed steel column is generally improved by the presence of intermediate [1] and edge stiffeners [2]/stiffened element [3,4] or to make a closed profile [5]. It can increase the strength and improve its overall behaviour. To recover the distortion capacity, a new innovative stiffened open complex channel section is selected for the study. Fundamentally, open cross-sectional profile has a very low distortion capacity. Hence, to formulate a closed profile, simple spacer plates are connected to the flanges of the open column section.

2 Review of Literature

Young and Yan [6] discussed a finite element analysis on design of fixed-ended plain channel columns by using ABAQUS. Failure modes computed by the finite element analysis agreed with the test results, whereas the axial shortening was unconservative; hence, a new design equation was proposed. Li and Chen [7] provided an analytical model for determining the elastic distortional buckling stress of open channel section subjected to either compression or bending about an axis perpendicular to the web. A sequence of column tests of intermediate length of cold-formed steel lipped channel sections with and without intermediate stiffeners in the flanges and web were conducted by Kwon et al. [8]. Modified formulas in the direct strength method for the sections failing in the interaction of local and distortional buckling were proposed. Batista [9] proposed an integrated design procedure for local–global buckling interaction of cold-formed steel columns. The design procedure was calibrated with the effective width, effective area and direct strength method for cold-formed steel columns. And also it is observed that the new design procedure is a simple and easy way to access the column resistance.

A study on the performance of stiffened and unstiffened channel with various aspect ratios, stiffeners sizes and slenderness ratios was discussed by Sheikh et al. [10]. Stiffeners change the section profile and enhance the resistance of the section. Very recently, Dinis and his research team [11–15] conducted a series of studies on local–distortional–global interaction, post-buckling behaviour and interactive failure analysis in distortional buckling of cold-formed steel lipped channel column. Investigations on selection of the geometric imperfection in numerical analysis of cold-formed steel rack columns were carried out by Bonada et al. [16]. Investigations on local–distortional–global buckling interactions of lipped channel columns were carried out by Santos et al. [17]. Landesmann and Camotim [18] studied the direct strength method design of steel column failed in distortional buckling. Current design rules in Australia (AS/NZS 4600) and North American Specifications (NAS) were not able to predict the column with fixed ends and warping fixity subjected to flexural torsional buckling. Hence, enhanced design rules for these conditions were proposed by Gunalan and Mahendran [19]. Post-buckling strength and behaviour of short thin-walled lipped channel column subjected to axial uniform compression were examined by Teter et al. [20]. The authors gave the highly sensitive boundary conditions for the post-buckling collapse state. Zhou and He [21] proposed a modified effective width formula for cold-formed steel column undergoing distortional buckling mode.

Very recently, a new idea for improving the distortional strength of intermediate thin-walled open column section has been proposed by several researchers [5]. Similarly, Veljkovic and Johansson [22] proposed an innovative idea for improving torsional stiffness of open thin-walled section. A series of studies a idea for improving distortional buckling behaviour of intermediate open column were discussed by Sukumar & Anbarasu [23,28]. Experimental investigation of the structural behaviour of CFS columns under fire conditions is carried out by Craveiro et al. [24]. In this study, it was observed that the end conditions and applied load level on CFS columns may affect significantly their fire performance. In this study, pin-ended condition was defined by a steel pin Teflon lined as a hinge and semi-rigid ended supports were materialized by blocking the hinge of the support with a set of steel plates. Experimental inquiry of the result of

Table 1 Research in partially closed column section

Topic	Conclusions	Year published
New approach to improving the distortional strength of intermediate length thin-walled open section columns [5]	The addition of the spacer plate helps in enhancing the torsional capacity of the open pallet racking section	2005
Design of thin-walled steel column with partially closed cross section [22]	Cover plates improves the torsional stiffness of the polygonal open column section	2006
Effect of connectors interaction in behaviour and ultimate strength of intermediate length cold-formed steel open columns [28]	Connectors increase the ultimate strength	2013
New approach to improve the distortion strength of intermediate length web stiffened thin-walled open columns [23]	The strength increases with an increase in depth of spacer plates and improves the behaviour	2013

single- and double-sided sheathing was deliberate on seismic performance of shear wall by Mohebbi et al. [25]

Table 1 displays the research achievements in improving the torsional capacity of various open cold-formed steel profiles over the last 10 years. From the above it is observed that, many of the researchers reported that the interaction between local and distortion buckling of the cold-formed steel sections and recently limited researchers gave the solution for them (Table 1). From the literature, it is observed that the study of the strength and behaviour of the open column section with spacer plate are scattered and limited. Though no studies have been reported on the distortional buckling behaviour of a new innovative stiffened complex channel section with spacer plates, these works elaborately discuss the details of such a study.

To arrive the cross-sectional dimensions and length of the column, an elastic linear finite strip buckling analysis is performed by using the CUFSM software. A detailed experimental investigation is carried out to examine the distortional buckling strength and behaviour of intermediate partially closed stiffened complex channel columns. A nonlinear finite element model is developed by using finite element analysis software ANSYS, and result is verified with the test result. The results obtained from the experiments and finite element analysis are compared with the theoretical calculations according to the direct strength method, North American Iron and Steel Specification [26] and Indian standard [27] for cold-formed steel structures. Following the substantiation of the

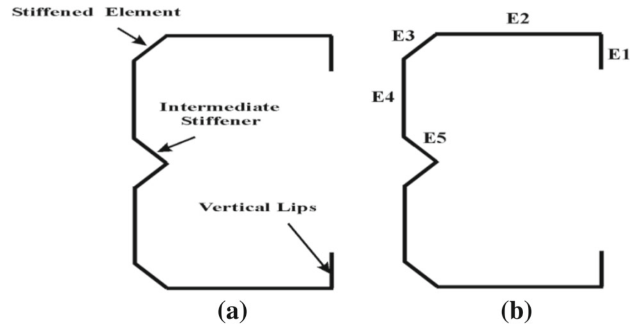

Fig. 1 Section geometries and cross-sectional dimensions

numerical model, a detailed parametric study is performed to evaluate the effect of the spacer plate on the strength and behaviour of the section by varying thickness, depth, spacing and slenderness of the spacer plate.

3 Experimental Investigations

3.1 Selection of Section

A new innovative stiffened open complex channel section is chosen for the study (Fig. 1). Figure 1 shows a distinctive cross section of the test specimen with nomenclature, and a detail of the specimen is presented in Table 2. To minimize local buckling, all the cross-sectional dimensions are arrived based on the specification of the Indian standard (IS 801-1975) for the cold-formed steel structures. To arrive dimension of the tested specimens, a detailed elastic linear finite strip buckling analysis is performed using CUFSM software. A typical multiple of the buckling half wave plot of specimen (SC-SP0-T1.6-d20) obtained from CUFSM software is illustrated in Fig. 2 and shows that specimen buckles distortionally for half wavelengths from about 76.2 to 1000 mm. Many of the researches have been carried out in the short and long column, but limited research is available in the intermediate column and also the results are scattered. Hence, the intermediate column is selected for the study with a length of 1000 mm, and the corresponding slenderness ratio is 74.

3.2 Specimen labelling

The details of specimen labelling are shown in Fig. 3. The term 'SC' specifies the type of cross section, term 'SP' specifies the number of spacer plates (0 no spacer plate, 1 one spacer plate, etc.), term 'T1.6' specifies the thickness of the section in mm, and the term 'd20' specifies the depth of the spacer plate in mm.

3.3 Experimental Setup

Totally, five pin-ended intermediate stiffened complex channel column sections with or without spacer plates are tested under axial compression. The length and cross-sectional

Table 2 Details of test specimen

Specimen labelling	Cross-sectional dimensions					Number of spacer plates
	E1 (mm)	E2 (mm)	E3 (mm)	E4 (mm)	E5 (mm)	
SC-SP0-T1.6-d0	15.20	35.30	25.20	100.30	25.30	0
SC-SP1-T1.6-d20	15.10	35.20	25.10	100.40	24.80	1
SC-SP2-T1.6-d20	15.30	35.20	25.30	100.30	23.00	2
SC-SP3-T1.6-d20	15.10	35.10	25.50	100.20	25.10	3
Fully closed section	15.00	35.10	25.30	100.20	25.00	Fully closed

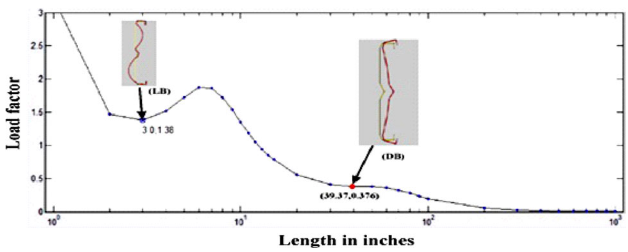

Fig. 2 Buckling plot of specimen—SC-SP0-T1.6-d20

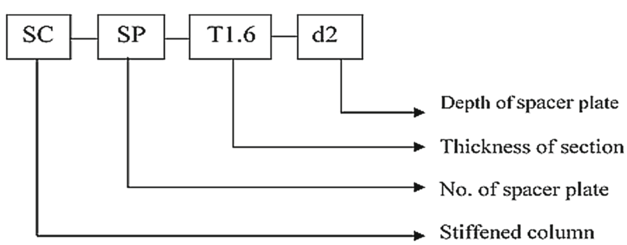

Fig. 3 Specimen labelling

dimension of the specimens are selected to meet with the distortional buckling mode. All the specimens are fabricated by press-braking operation. Locally available cold-rolled sheets of 1.6 mm thickness are used with yield stress of 270 N/mm^2 and Young's modulus of 2E5 N/mm^2. All the specimens had a length of 1000 mm.

In the entire experimental study, cross-sectional dimensions are constant, but variable is the number of the spacer plate (Fig. 4). To increase distortional buckling strength, a spacer plate is connected to the lips of the section using self-tapping screws as shown in Fig. 5. To ensure uniform load distribution during the test, the specimens are tested with two rigid milled plates, one each at the top and bottom of the specimen (Fig. 5). The load and boundary conditions applied at the centre of gravity (CG) of the section will get distributed uniformly over the cross section. The specimens are mounted between the plates at either end. At each end, rubber gaskets were placed to facilitate the pinned boundary condition at the supports [28]. The pin-ended bearings allow rotation about both axis, but rotations about the perpendicular axis and twist rotations are constrained

Teter [20], as shown in Fig. 5. Initially, verticality and levelling of the specimen are checked. The schematic test setup is shown in Fig. 5. All the specimens are tested in a loading frame of capacity 100 T, and hydraulic machine of capacity 400 kN is used to apply the axial compressive load on the specimen. The applied load and transducer readings are recorded using a data acquisition system.

4 Finite Element Model

The stiffened cold-formed steel complex channel section, spacer plates and reference points are defined individually. Measured centre line dimensions of stiffened complex channel sections and spacer plates are modelled using SHELL 181 element available in the ANSYS material library. In all cases, the columns are assumed to be pinned at the ends with respect to both the principal axis and loaded through the geometric centroid of the cross section (the pin-ended bearings allow rotation about both axis, but rotations about the perpendicular axis and twist rotations are constrained, as shown in Figs. 5, 6). The boundary conditions are accomplished using two reference points (RP-1 and RP-2) that are connected to the column via node-to-node constraint available in ANSYS. The reference points are modelled using structural mass 3D element. A concentrated load is applied statically at the reference point (RP-1) as shown in Fig. 6, thus applying uniform distribution of pressure at the top end of the column [29]. The residual stresses are not integrated in the finite element analysis because all the test specimens are fabricated using press-braking process [30]. Cold forming process is not considered in the finite element model because the effect of rounded corners was found to be insignificant [31]. After comprehensive mesh convergence study, a finite element mesh size of 10 × 10 mm is used to analyse the stiffened open complex channel section with or without spacer plates. Coupling option used for connection is crucial [3]. A typical finite element model is reported in Fig. 6.

First, linear elastic eigenvalue buckling analysis is performed to recognize the probable buckling mode and elastic buckling loads. The failure mode for most of the specimens

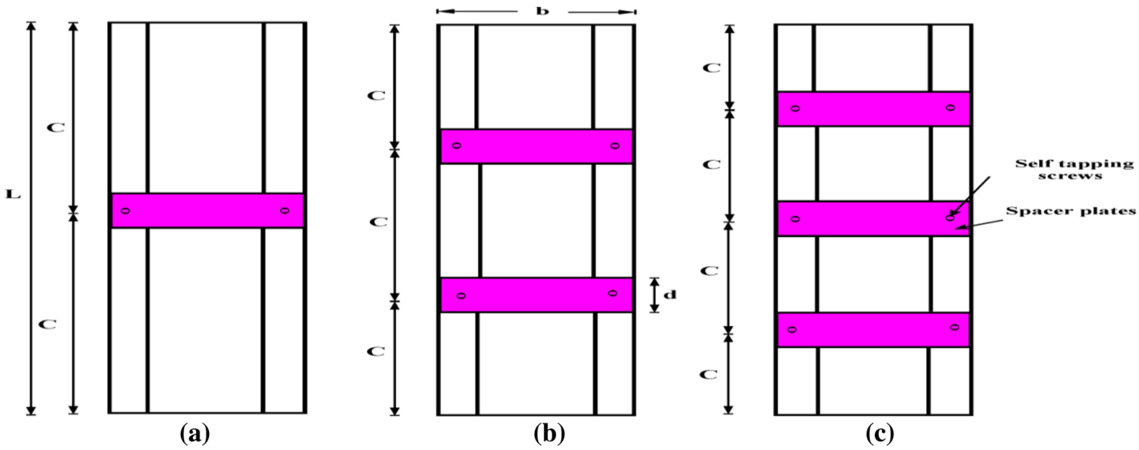

Fig. 4 Layout of spacer plates

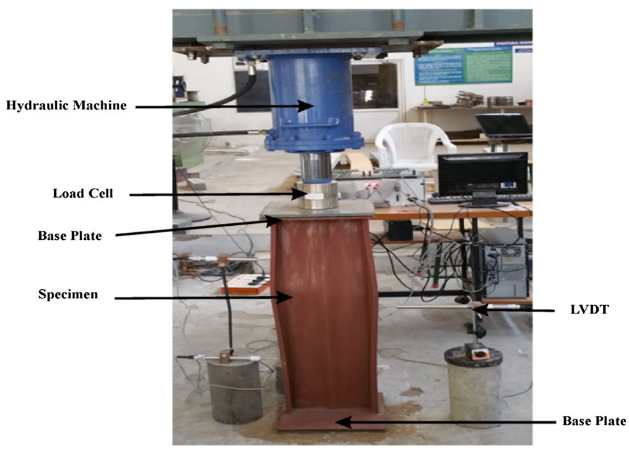

Fig. 5 Experimental setup

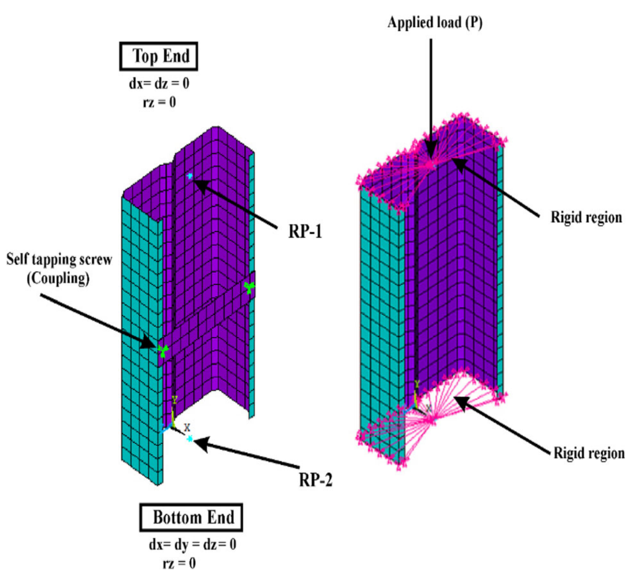

Fig. 6 Details of finite element model

is distortional buckling about the axis. Consequent to the nonlinear static buckling analysis, both the material and geometric nonlinearities are performed on the geometry of the member after applying imperfection. In the finite element models, the maximum amplitude of the imperfection equals to one time the thickness (1T) of the specimen is applied; this is equal to the mean values of deliberate imperfections reported by Schafer and Pekoz [32]. The material nonlinearity is chosen as elastic perfectly plastic which is defined by a bilinear stress curve with a tangent modulus of 2E4 N/mm^2.

5 Result and Discussion

Experimental surveillance of three series of sections is analysed. The load vs axial deformations (Fig. 7) predicted by ANSYS are compared with those of the experiments. The buckled shape of all the tested column sections is shown in Fig. 8, and also it is observed that the prime mode of failure of the entire column is distortional buckling. The column strength obtained from the test (P_{EXP}) is compared with finite element analysis (P_{ANSYS}), and results are shown in Table 3. The objective of this investigation is to evaluate the strength and behaviour of stiffened cold-formed steel complex channel section with an equal cross-sectional area, varying the number of spacer plates. Local, distortional and flexural torsional buckling is observed experimentally and confirmed by the numerical analysis (ANSYS) as shown in Figs. 9 and 10. All the specimens are tested to reach its ultimate value. All the specimens are having an equal cross-sectional area, while specimens SP0 (Fig. 9) and SP1 failed by distortional buckling, specimen SP2 is failed by mixed local flexural torsional buckling, specimen SP3 is failed by flexural torsional buckling (Fig. 10), specimen SCS is failed by local buckling, and its ultimate loads are 73.04, 83.33, 92.10, 96.59 and 81.70 kN, respectively. The ultimate compression capacity of the

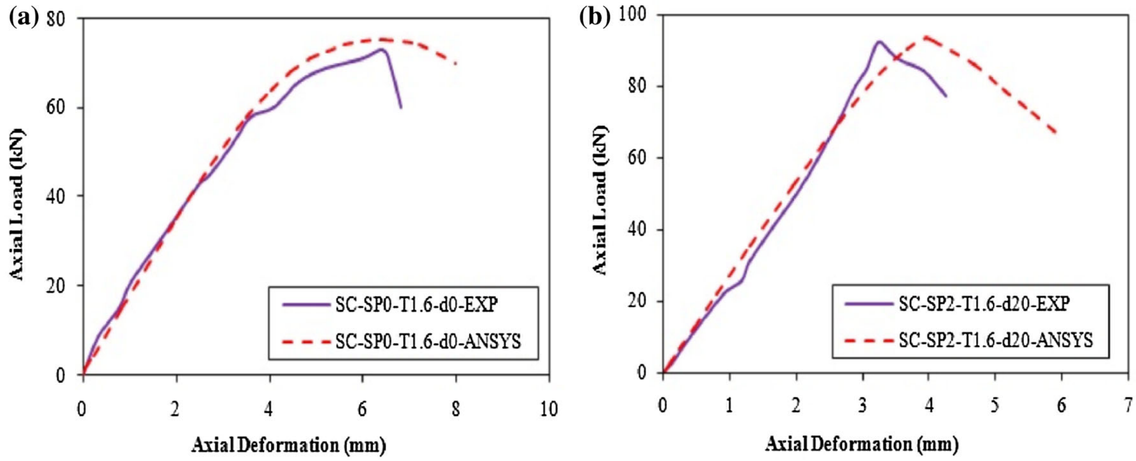

Fig. 7 Comparison of load deflection curve for Specimen **a** SC-SP0-T1.6, **b** SC-SP2-T1.6

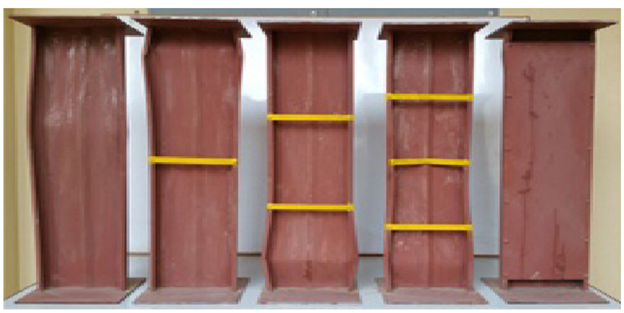

Fig. 8 Specimens after testing

fully closed section is smaller than all the specimens. In the fully closed section, local buckling and wobbling occurred in between the connections of the spacer plates; hence, the ultimate compression capacity of the fully closed section is smaller than all the specimens.

The percentage of increase in buckling strength is listed in Table 2. From this result, it is obviously observed that the spacer plates increase the stiffness of the section and improves the failure mode from distortional buckling mode to overall buckling mode. Since the spacer plate improves the torsional rigidity of the open column section, specimen with three spacer plates performed well against distortional buckling and also have the elevated capacity than all other column sections. Based on the ultimate strength and buckling behaviour, proposed column section with three spacer plates is the most efficient section.

5.1 Substantiation of the Finite Element Model

The load vs axial deformations (Fig. 7) and failure modes (Figs. 9, 10) predicted by ANSYS are compared with those of the experiments. Moreover, the failure modes obtained from the ANSYS are equivalent to the experimental failure modes. These figures reveal a good agreement between ANSYS and experiments and also bear out the competency of the developed finite element model in predicting the ultimate load and failure modes. The column strength and failure modes predicted numerically (P_{ANSYS}) are compared besides that experimentally (P_{EXP}) as reported in Table 3, and a good conformity is achieved. The mean and standard deviation of

Table 3 Comparison of experimental and finite element analysis results

Details of specimens		Ultimate load		P_{ANSYS}	% of increase in load (P_{EXP})	Failure mode
ID	Labelling	P_{EXP} (kN)	P_{ANSYS} (kN)	P_{EXP}		
SP0	SC-SP0-T1.6-d0	73.04	75.19	1.03	–	DB
SP1	SC-SP1-T1.6-d20	83.33	83.50	1.00	14.08	DB
SP2	SC-SP2-T1.6-d20	92.10	93.68	1.02	26.09	LB+FTB
SP3	SC-SP3-T1.6-d20	96.59	100.79	1.04	32.24	FTB
SCS	Fully closed section	81.70	83.05	1.03	11.85	LB
Mean				1.02		
SD				0.016		

LB local buckling, *DB* distortional buckling, *FTB* flexural torsional buckling

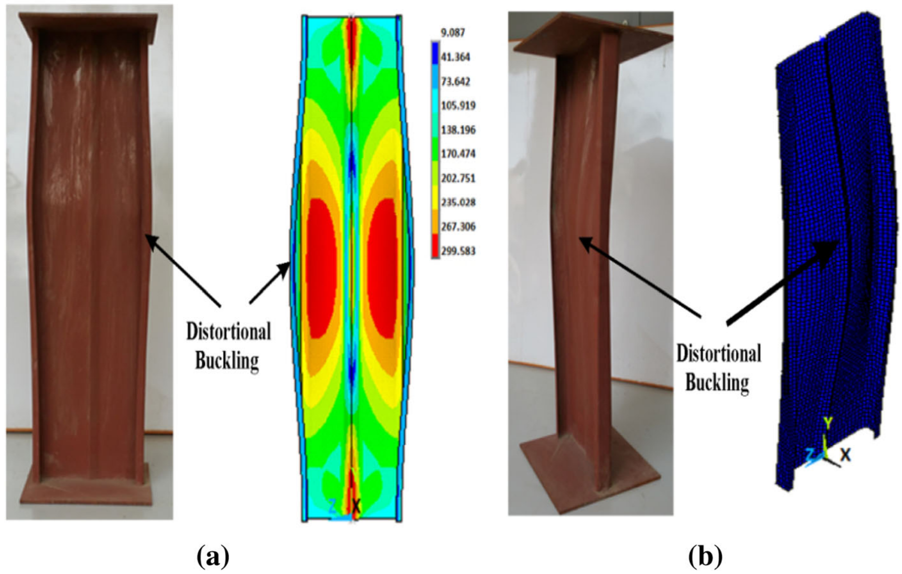

Fig. 9 Distortional buckling for specimen—SC-SP0- T1.6-d0

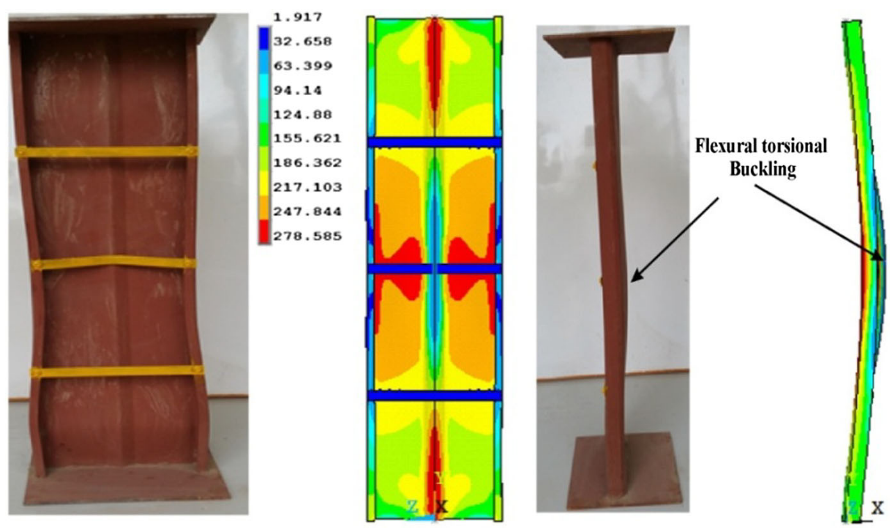

Fig. 10 Flexural torsional buckling for specimen—SC-SP3-T1.6-d0

Table 4 Comparison of experimental results with code specification

Particulars	P_{EXP}	P_{DSM}	P_{AISI}	P_{IS}
Ultimate load (kN)	73.04	77.64	82.33	93.32
Mode of failure	DB	DB	DB	FTB

DB distortional buckling, *FTB* flexural torsional buckling

P_{EXP}/P_{ANSYS} are 1.02 and 0.016, respectively. From this study, it is observed that developed finite element model closely predicts the strength and behaviour of the test section.

5.2 Comparison of Experimental Results with Code Specification

Table 4 shows the comparison of experimental results from the fully opened section with the design strength calculated using the direct strength method (DSM), North American Iron and Steel Specification (AISI S 100-2007) and Indian standard (IS 801-1975) for the cold-formed steel structures. The evaluation shows that direct strength method and North American Iron and Steel Institute specifications are conservative, whereas Indian standard is unconservative. This investigation shows that further research is needed to incorporate the design premise of Indian standard (IS 801-1975) for the cold-formed steel structures, which is related to distortional buckling.

6 Parametric Studies

From this experimental investigation, it is observed that the open column section with spacer plates increases the distortional buckling strength and also observed that the finite

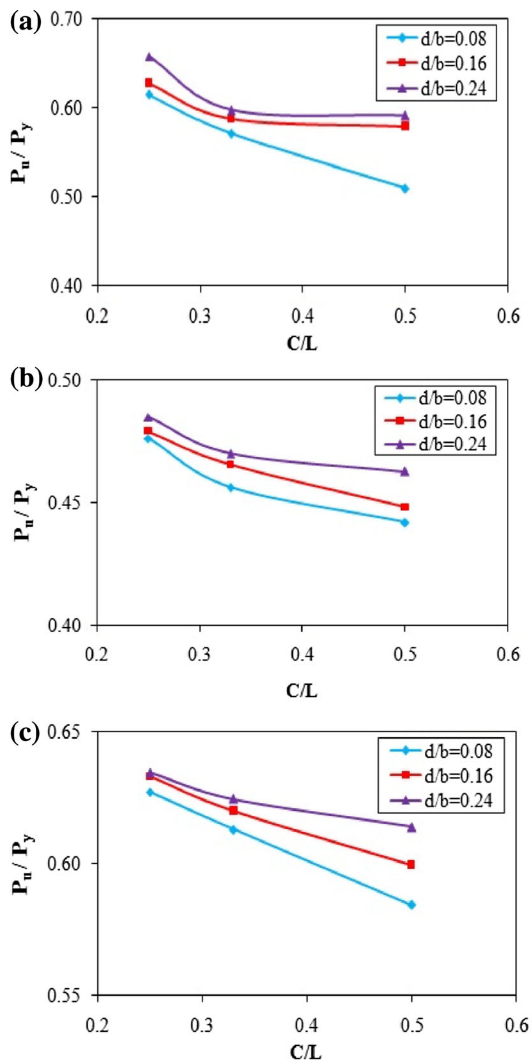

Fig. 11 Effect of spacer plate variation **a** section with 1.6 mm thickness, **b** section with 2 mm thickness, **c** section with 3 mm thickness

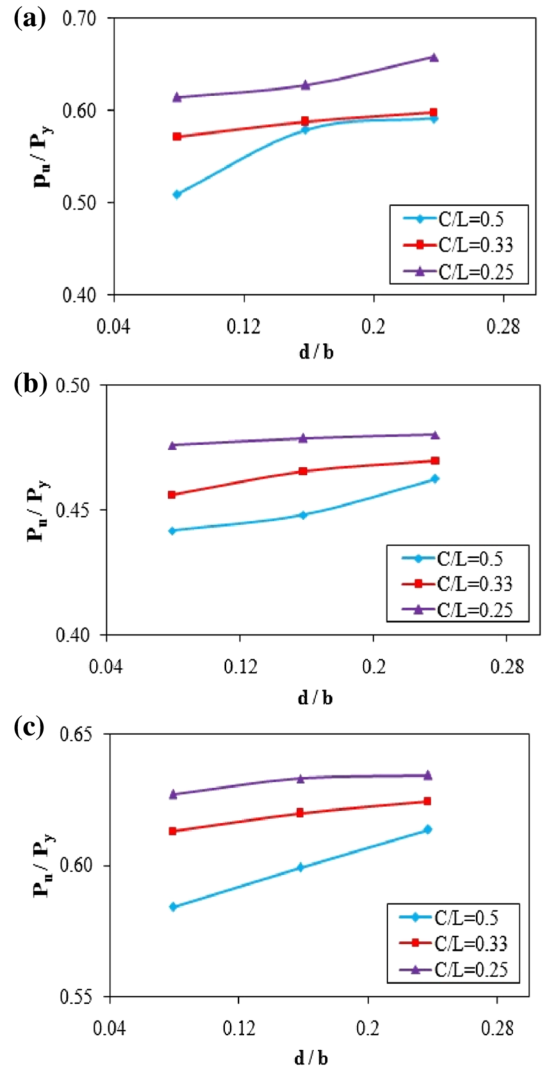

Fig. 12 Effect of spacer plate slenderness **a** section with 1.6 mm thickness, **b** section with 2 mm thickness, **c** section with 3 mm thickness

element results well established by the test results. Hence, the verified finite element model is used for a meticulous parametric study to investigate the effects of the cross-sectional geometries of spacer plate such as a centre-to-centre distance between spacer plate (*C*), number of spacer plate, depth of the spacer plate (*d*) and thickness of the spacer plate (*T*) on the distortional buckling strength and behaviour of stiffened complex open channel section. The labelling rule and details of spacer plate variations with taxonomy used in this parametric study are clearly defined in Figs. 3 and 5, respectively. The depth of the spacer plate (*d*) is varied from 20 to 60 mm with increment of 20 mm, number of spacer plates varies from 1 to 3, thicknesses (*T*) of the spacer plates are taken as 1.6, 2 and 3 mm, and width of the spacer plate (*b*) is taken as 253 mm.

6.1 Effect of Centre-to-Centre Distance Between Spacer Plates to the Length of the Column (*C*/*L*)

Figure 11 illustrates the relationship between the normalized ratios of (*C*/*L*) and P_u/P_y for different magnitude of *d*/*b* (0.08, 0.16 and 0.24) and dissimilar thickness (1.6, 2 and 3 mm). For an example, Fig. 11a, it can be observed that for 1.6 mm thickness with a particular *d*/*b* ratio, the P_u/P_y ratio increases with the decrease in space of spacer plates (*C*) and P_u/P_y ratio is reduced by increasing *C*/*L* ratio.

From this, it is concluded that the spacing of spacer plates (*C*) decreases, the ultimate strength of the sections increases, which may contribute to the reduction in the buckling length of the section and enhancement of load sharing between the spacer plates and improve their distortional buckling behaviour. From this study it is observed that, to decreasing the

Table 5 Finite element analysis results

Specimen labelling	Details of spacer plates			C/L	d/b	P_U (kN)	$\frac{P_U}{P_Y}$
	Number	Depth (d) mm	Interval (C) mm				
SC-SP0-T1.6-d0	0	0	0	0.000	0.000	75.19	0.46
SC-SP1-T1.6-d20	1	20	500	0.500	0.079	83.50	0.51
SC-SP2-T1.6-d20	2		333	0.333	0.079	93.68	0.57
SC-SP3-T1.6-d20	3		250	0.250	0.079	100.79	0.61
SC-SP1-T1.6-d40	1	40	500	0.500	0.158	95.04	0.58
SC-SP2-T1.6-d40	2		333	0.333	0.158	96.44	0.59
SC-SP3-T1.6-d40	3		250	0.250	0.158	103.00	0.63
SC-SP1-T1.6-d60	1	60	500	0.500	0.237	97.00	0.59
SC-SP2-T1.6-d60	2		333	0.333	0.237	98.00	0.60
SC-SP3-T1.6-d60	3		250	0.250	0.237	108.00	0.66
SC-SP0-T2-d0	0	0	0	0.000	0.000	99.91	0.37
SC-SP1-T2-d20	1	20	500	0.500	0.079	119.42	0.44
SC-SP2-T2-d20	2		333	0.333	0.079	123.27	0.46
SC-SP3-T2-d20	3		250	0.250	0.079	128.65	0.48
SC-SP1-T2-d40	1	40	500	0.500	0.158	121.12	0.45
SC-SP2-T2-d40	2		333	0.333	0.158	125.79	0.47
SC-SP3-T2-d40	3		250	0.250	0.158	129.43	0.48
SC-SP1-T2-d60	1	60	500	0.500	0.237	125.00	0.46
SC-SP2-T2-d60	2		333	0.333	0.237	126.97	0.47
SC-SP3-T2-d60	3		250	0.250	0.237	131.00	0.48
SC-SP0-T3-d0	0	0	0	0.000	0.000	158.23	0.53
SC-SP1-T3-d20	1	20	500	0.500	0.079	174.61	0.58
SC-SP3-T3-d20	2		333	0.333	0.079	183.15	0.61
SC-SP3-T3-d20	3		250	0.250	0.079	187.45	0.63
SC-SP1-T3-d40	1	40	500	0.500	0.158	179.11	0.60
SC-SP3-T3-d40	2		333	0.333	0.158	185.27	0.62
SC-SP3-T3-d40	3		250	0.250	0.158	189.21	0.63
SC-SP1-T3-d60	1	60	500	0.500	0.237	183.44	0.61
SC-SP3-T3-d60	2		333	0.333	0.237	186.61	0.62
SC-SP3-T3-d60	3		250	0.250	0.237	189.59	0.63

centre-to-centre distance of spacer plates (C), the increases the strength (P_u) and improves the behaviour from distortional buckling to overall buckling. Enhanced column strength values are obtained upon decreasing centre-to-centre distance of the spacer plate (C) and increasing the depth of the spacer plate (d). Similar results are obtained for all thickness considered in the study.

6.2 Effect of Depth of Spacer Plates to the Length of the Column

The effect of the depth of spacer plates and P_u/P_y ratio is reported in Fig. 12 for three depths (20, 40 and 60 mm) and three spacing of the plate (250, 333 and 500 mm) with three diverse thicknesses of the section (1.6, 2 and 3 mm). From the figure, it can be observed that the P_u/P_y ratio increases with an increase in the depth of the spacer plates. Also, it is observed that the centre-to-centre distance between spacer plate (C), number of spacer plate, depth of the spacer plate (d) and thickness of the spacer plate (T) had a momentous effect on the distortional buckling strength and behaviour of stiffened complex open channel section. The ultimate load of the column while varying the depth, thickness and number of spacer plates is presented in Table 5.

7 Summary and Conclusion

The current study has undertaken an experimental, numerical and theoretical approach to monitor the strength and buckling behaviour of partially closed intermediate stiffened complex channel section under axial load. Numerical analysis is also carried out by using ANSYS software and accounted for the material and geometric nonlinearities. Totally, 5 specimens are tested and results are compared numerically. A parametric study is carried out to investigate the effect of thickness, depth and spacing of the spacer plate on the strength and buckling behaviour of the specimens. The results acquired from experimental and finite element analysis are compared with the computed resistance by direct strength method, North American Iron and Steel Specification and Indian standard for cold-formed steel structures. Based on the results presented herein, it looks reasonable to draw out the following conclusions.

1. The developed finite element model efficiently simulated the buckling behaviour of axially loaded intermediate stiffened partially closed complex channel section.
2. The open column fails by pure distortional buckling whereas due to the provisions of spacer plates the partially closed column fails by mixed local and flexural torsional buckling.
3. The spacer plate improves the torsional rigidity and increases the stiffness of the section.
4. Thickness, depth and spacing of spacer plates significantly affect the overall performance of the sections.
5. For partially closed, intermediate stiffened complex channel section, the ratio of the centre-to-centre distance of the spacer plate to the length of the column (*C*/*L*) and spacer plate slenderness (*d*/*b*) appears to have a predominant effect on column strength up to a value of 0.25 and 0.158, respectively. Beyond this range, the rate of increase in the column strength is marginally compared to open section, because *C*/*L* ratio increases more than 0.25 increases the buckling length of the section between the spacer plates and reduces the load sharing between them.
6. Similarly, spacer plate slenderness (*d*/*b*) increases more than 0.158, the magnitude of increase in column strength is very minimum because local buckling occurs at earlier.
7. Test results of the open column section are compared with the current design guidelines available for the cold-formed steel structures. The evaluation shows that direct strength method and North American Iron and Steel Institute specification are conservative, whereas Indian standard is unconservative.

Based on the ultimate strength and behaviour, proposed column section with three spacer plates is the most efficient section.

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